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Agency Name:	National Science Foundation
Agency Tracking Number:	**2210827**
Organization:	
NSF Program:	STATISTICS
PI/PD:	Mei, Song
Application Title:	Mean Field Asymptotics in Statistical Inference: Variational Approach, Multiple Testing, and Predictive Inference

Review 1

Rating:

Excellent

Review:

Summary

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

Overview:
The proposal aims to develop new methods and theoretical techniques for variational inference, FDR control and predictive inference, to accommodate model misspecification to some extent.

+ The introduction, background, and preliminary results are well written and motivate the theoretical topics satisfactorily.
+ The research plan is well organized and carefully reasoned.
+ The PI has solid preliminary works and the expertise to conduct the proposed research.

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

+ The PI will use the related topics and problems in his teaching of two graduate courses on theoretical statistics and statistical learning.
+ The PI will organize workshops and invited sessions to disseminate the research outcomes.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

Summary Statement

The proposal is well written and the proposed research is clearly argued and planned. This is outstanding proposal that deserves a high priority of support.

Review 2

Rating:

Very Good

Review:

Summary

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The proposal lists three major problems of interest in the context of high dimensional Bayesian inference, which includes variational inference via TAP approximation, asymptotics of Bayesian FDR /TPP for a procedure which controls Frequestist FDR, and conformal inference in the bayesian setting. The problems considered are of interest, and the proposed approaches to solve them seem well suited. The PI has the right background to solve the problems outlined, and a very good publication record. Moreover, he has developed a collaborative network of strong researchers who are well equipped to work on the problems outlined.

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

The proposed research plan is timely, well spelled out, and will make a good contribution in the field of high dimensional statistics. In particular, this will have implications to both statistics and machine learning, and will borrow/develop probabilistic tools along the way. The proposal is on on theory side, and does not plan on developing code/software for general use. The PI does not have a strong record of mentoring students, though that is expected for someone with a recent PhD. He has involved both undergraduate and PhD students in his research as part of his research agenda.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

Summary Statement

In summary, I would classify the proposal as very good, albeit a bit on the theory side. The PI's strong record makes me believe the PI will carry out a significant portion of the outlined research to success.

Review 3

Rating:

Very Good

Review:

Summary

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

Strengths:
(1) Attempting to develop results on FDR control and on prediction sets which are ``adaptive'', i.e. have certain optimality when some assumption holds (that the prior is well-specified)
and are valid with few/no assumptions is an interesting direction to pursue.
(2) The vast majority of the literature on FDR control and on prediction sets has solely focussed on Type I error (or validity) often ignoring Type II error (or size). The strong focus of this proposal on studying Type II error/size is nice.
(3) The PI is very well qualified to accomplish the goals of the proposal.

Weaknesses:

(1) The focus on sharp theoretical results, under high-dimensional asymptotics, seemingly necessitates the study of stylized models (large portions of the proposal focus on linear models, with independent Gaussian covariates). While these setups are already mathematically challenging, it is difficult to see them strongly
impact statistical methodology/practice.
(2) In both the prediction sets, and FDR parts, the proposed methods essentially ``wrap'' Bayes-inspired quantities into general-purpose methods to obtain frequentist guarantees. This to some
extent limits the methodological novelty, and instead squarely focuses on theoretical aspects.
(3) Possibly due to space limitations, many very ambitious parts of the proposal have very few details. For instance, in the FDR part, the PI proposes to study Knockoffs, mirror statistics, and the Bayes-inspired method proposed by the PI in order to establish optimality, but no details are given on what the challenges are here. Similarly, in the TAP part, how difficult would it be to develop results for general priors? How does the PI hope to address those challenges?

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Strengths:

(1) The PI has already taught an advanced graduate class (with publicly available lecture notes) on the topics of the proposal.
(2) The PI has plans to involve graduate and undergraduate students in the project, and organize workshops at Simons, MSRI, JSM etc. The PI is a co-organizer of an online seminar series on Math of ML.

Weaknesses:

(1) I am generally concerned that most of the proposed research is too advanced to form the basis of successful undergraduate projects, and there aren't enough details on how the PI plans to accomplish this.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

N/A

Summary Statement

The PI proposes to address two, somewhat loosely connected challenges, (1) studying (under high-dimensional, proportional asymptotics) the landscape of objective functions that arise in variational inference (2) designing Bayesian procedures,
with frequentist ``safety'' guarantees,
for controlling FDR and for constructing prediction sets.

Overall, I found the proposal to be clear and well-written. It aims to address questions which are challenging and interesting. The PI
is uniquely suited to address these questions. I would rate the proposal in the top third of proposals I reviewed.

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